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Original Investigation

Analysis of self-reported declared physical activity among female and male first-year students using the International Physical Activity Questionnaire - Short Form (IPAQ-SF)

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Purpose: The present study aimed to assess the PA levels in first-year Slovak university students, with an analysis of differences in the amount of energy expenditure related to PA, the intensity and frequency of PA undertaken by them according to gender and BMI category.
Methods: The research was conducted among 1,665 first-year university students from all public universities in Slovakia. The International Physical Activity Questionnaire - short form (IPAQ-SF) was used to assess PA levels, and information on body weight and height was used to calculate body mass index (BMI). A total of 1,314 questionnaires were included in the final analysis.
Results: The results of our study indicate that more than 76% of students engage in moderate or high levels of PA, with over 41% achieving a high PA level. Comparison of the energy expenditure of male and female students according to the IPAQ-SF protocol clearly confirmed that women are less physically active than men ($P \leq .001$). The analysis of differences in energy expenditure between underweight, normal-weight, and overweight/obese subjects showed no statistically significant differences within each PA level, but underweight participants spent significantly more time sitting than normal-weight individuals ($P = .023$). Additionally, underweight individuals had significantly lower energy expenditure for TPA compared to overweight/obese individuals ($P = .034$).
Conclusions: An interesting, albeit unexpected, finding that contradicts common assumptions is the observation that underweight students spend significantly more time sitting than those with normal weight. Further research should explore potential explanations for this phenomenon. Psychological factors, such as depression, anxiety, or eating disorders, may contribute to reduced appetite, increased fatigue, and subsequently, lower PA engagement.

Keywords: physical activity; IPAQ; students; body mass index; Slovakia

Introduction

Physical activity (PA) in early adulthood is a key determinant of well-being[1] influencing not only fitness levels but also the mental health of students.[2] PA trends are rapidly evolving as technology evolves and are increasingly influenced by social media, and mobile applications.[3,4] They are also shaped by societal changes and health awareness[5], particularly in terms of knowledge regarding the relationship between insufficient PA and obesity.[6] Furthermore, they are affected by a period of significant life transitions young people experience and changes in body image perception.[7]
The stage of early adulthood and the transition from school to university is a critical period in a young person's life, marked by the shift toward greater personal responsibility for health and life. The time spent at university is associated with a radical change in life patterns,[8,9] including, among others, the students having to face increased demand on being independent, changes in peer groups, new aspects of social life, and increased workload related to their academic responsibilities. Personal values are crucial in shaping behaviour, decision-making, goal-setting, and life expectations, making them a key factor in academic life.[10] It is highlighted that the most common lifestyle-related behavioural changes in university students involve eating habits, physical activity levels, sleep patterns, and stress perception.[11] Research findings document that health behaviours related to attention to adequate PA deteriorate during the transition from school to university and tend to persist into later stages of life.[12] The new university environment can have positive and negative effects, potentially leading to either the adoption or reinforcement of favourable or unfavourable health behaviours. It has been shown that,[13] in the context of PA, social support, including support from friends, is more strongly associated with PA than support from family. However, published research consistently reports insufficient levels of PA among students.[14,15] While conclusions of a recent literature review[16] suggest that PA levels among students are satisfactory, the authors highlight significant discrepancies in the findings. These variations may be attributed to cultural differences, differences in educational systems, and the distinct profiles of universities and fields of study.
In Slovakia, comprehensive scientific studies dealing with physical activity among university students have been absent over the past decade. Existing research is limited to studies

conducted exclusively within a single university, which limits the possibilities of generalising the results to the whole generation of university students in the country. The low level of PA of Slovak university students at the local level has been noted by experts throughout Slovakia: in the east - Zusková et al.[17] at UPJŠ and TUKE in Košice, in the centre Krafčík and Görner[18] at UMB Banská Bystrica, and in the west of Slovakia by Cepková[19] at STU in Bratislava and Broďáni, Špániková[20] at UKF Nitra. Despite a significant number of papers on the declining trend in PA across different age and social groups, the phenomenon of decreasing PA levels among university students in Slovakia remains inadequately researched at the national level. It, therefore, seems reasonable to conduct a diagnosis of the level of physical activity of as many Slovak students as possible from various academic centres throughout the country. The present study aimed to assess the PA levels in first-year Slovak university students, with an analysis of differences in the amount of energy expenditure related to PA, the intensity and frequency of PA undertaken by them according to gender and BMI category.

Methods

Participants

The research was conducted among 1,665 first-year university students from all public universities in Slovakia. For the purposes of this study, first-year students were defined as individuals enrolled in a bachelor's degree program for the first time following the completion of secondary education. Students who were retaking their first year of study were excluded from the sample.

Participation in the survey was anonymous and voluntary. The protocol was approved by the Human Research Ethics Committee. At the beginning of the questionnaire participants were informed about intentions of using questionnaire in the study and every participant agreed before filling it out. Data collection and administration for the survey were conducted using the Google Forms application. The data were collected by a team of trained professionals until December 2022, and the process was completed in February 2023. Ten instructed students of UPJŠ reached out to students at all public universities in Slovakia through Instagram and Facebook social networking sites and sent a link to the form to students who expressed interest in completing the questionnaire through these networks. Thus, the link was directly accessible only to the students contacted and was not publicly posted anywhere. There are 20 public universities in Slovakia, and all these schools were contacted. Participants were contacted via the official university profiles of the physical education departments of the respective universities (vice-deans and study advisors) through student associations and student councils with a request to share the link among students of the respective schools. The link was not made public intentionally to prevent duplicate responses and minimize involvement of respondents outside the target population. Although the sample was not selected through random sampling, efforts were made to ensure high demographic diversity, thereby partially reducing the risk of systematic bias. Furthermore, the questionnaire included basic sociodemographic variables, allowing for post hoc analysis of sample composition and comparison with official data on the Slovak student population.

Students who were training professionally in sports or studying physical education were excluded from the study. The study included only students engaged in recreational sports, explicitly excluding those involved in competitive sports. The physical activity of physical education students and competitive athletes results largely from compulsory classes held both as part of their university studies and training, which does not allow for voluntary physical activity to be considered. More information about the sample (sociodemographic details such as age, gender, residence, and nationality) is provided in the study by Bukova et al.[21]

The International Physical Activity Questionnaire - short form (IPAQ-SF) was used to assess PA levels. Each participant provided self-reported data on body mass and height, which were then used to calculate BMI. The participants were divided into three BMI categories (< 18.5 - underweight; 18.5 - 24.99 - normal weight; ≤ 25 - overweight and obese (due to the number of people in the group).

Following the guidelines for cleaning and analysing the results of the IPAQ-SF questionnaire (Guidelines IPAQ, November 2005), questionnaires with missing data on time spent exercising and those in which the total time reported for walking, moderate and intense PA variables was greater than 960 minutes were excluded from the analysis. Finally, the results collected from 1,314 people were eligible for analysis. Women accounted for 69.48% (n= 913) of respondents, while men represented 30.52% (n= 401). The average age of the respondents was 20.71±1.41 years (women 20.61±1.37 and men 20.91±1.46 years). The respondents were students from three fields of study: medicine studies (MS), technical studies (TS) and humanities studies (HS). MS students accounted for 29.60% of respondents (254 females and 135 males), TS students for 23.14% (151 females and 153 males), and HS students for 47.26% (508 females and 113 males).

Instruments

The International Physical Activity Questionnaire - Short Form (IPAQ-SF)[22] was used in our research. IPAQ-SF is a self-reported questionnaire evaluating the PA levels in adults aged 15 to 69 years. In the present study, the International Physical Activity Questionnaire – Short Form (IPAQ-SF) was employed to assess participants' physical activity levels. IPAQ-SF is a widely used and internationally recognized instrument for monitoring population-level physical activity.[22] Although the Slovak version of the questionnaire has not yet been formally validated, multiple studies conducted in culturally and linguistically related Central European countries - including Slovenia,[23] Hungary,[24] the Czech Republic,[25] and Poland[26] provide empirical support for its psychometric properties in similar populations. Furthermore, a cross-national comparison conducted by Líška et al.[27] among university students from Poland, Slovakia, and the Czech Republic confirmed the utility and comparability of IPAQ-SF across countries. The IPAQ-SF consists of 7 items and records PA at vigorous intensity (hard effort, causing an increased breathing rate and heartbeat, e.g., running, aerobics, sports cycling, tennis), moderate-intensity activities (average effort with a slightly increased breathing rate and heartbeat, e.g., swimming, yoga, or recreational cycling) and walking (marching, Nordic walking, walking). Additionally, the IPAQ-SF includes an assessment of time spent sitting. The participants report activities lasting longer than 10 minutes in the 7 days prior to completing the questionnaire. PA level was expressed as Metabolic Equivalent of Task [MET] and calculated by multiplying the MET assigned to each activity (vigorous - 8 MET, moderate - 4 MET, and walking - 3.3 MET) by the number of days it was performed during the previous 7 days. Based on the results obtained from the IPAQ-SF questionnaire, the total physical activity (TPA) of the students was calculated in units of MET - min/week and time spent sitting was calculated in unit's

min/week. The total PA of the participants was divided into 3 categories: high, moderate, and low according to scoring IPAQ protocol.[22]

Statistical analysis

Statistical analysis was performed using Statistica 13.3 (TIBCO Statistica Software Inc., Palo Alto, CA, USA 2017). The statistical significance level was set at $P \leq .05$. Frequency analysis was conducted to determine the overall numbers and percentages of respondents by gender, BMI category (underweight, normal weight, overweight, and obese), PA level, and field of study, were examined. Pearson's chi-squared test was used to assess the associations between qualitative variables (gender × PA level; gender × BMI category). Using descriptive statistics (means, standard deviations, medians, quartiles), the analysis presented the magnitude of energy expenditure, frequency, and duration of PA among respondents. The normality of the distribution of the study variables was verified using the Kolmogorov-Smirnov test. Although all variables followed a normal distribution, Levene's test indicated a lack of homogeneity of variance. Further analysis was based on non-parametric statistical methods. The significance of differences in energy expenditure between men and women was assessed using the Mann-Whitney U-test. The Kruskal-Wallis test was used to analyse differences in energy expenditure across BMI categories. If a statistically significant result was obtained, a post hoc analysis was conducted, using Dunn's test with a Bonferroni correction.

Results

Following the guidelines provided by the questionnaire authors, respondents were classified into three PA levels: low (23.44%, n= 308), moderate (35.46%, n= 466), and high (41.10%, n= 540). Within gender categories, among women, 25.10% (n= 229) had a low PA level, 36.91% (n= 337) had a moderate level, and 38.01% (n= 347) had a high level, while among men, 19.70% (n= 79) had a low PA level, 32.17% (n= 129) had a moderate level, and 48.13% (n= 193) had a high level. The Pearson's chi-squared test showed a statistically significant relationship (P= .002) between gender and PA levels. Among those with normal weight, 22.32% (n= 206) achieved low PA, moderate levels were found in 36.84% (n= 340), while high levels were recorded by 40.85% (n= 377) of respondents. Among underweight individuals, 33.10% (n= 47) had a low PA level, 30.28% (n= 43) had a moderate level, and 36.62% (n= 52) had a high level. Among overweight and obese respondents, 22.09% (n= 55) showed a low PA level, 33.33% (n= 83) a moderate level, and a high level was found in 44.58% (n= 111). The chi2 test indicated a statistically significant relationship (P= .046) between BMI categories and PA levels.

Total physical activity (TPA) values recorded in men were significantly higher than in women ($P \leq .001$) (Table 1). Compared to women, men engaged in a significantly greater number of days per week [days/week] of vigorous ($P \leq .001$), moderate (P= .008), and walking (P= .013) intensity activities. Additionally, men spent significantly more time per day [min/day] on vigorous ($P \leq .001$) and moderate ($P \leq .001$) intensity activities. Weekly energy expenditure (WEE) [MET min/week] for men in vigorous ($P \leq .001$) and moderate ($P \leq .001$) intensity activities was also significantly higher than for women. However, gender did not significantly differentiate WEE [MET min/week] and time spent per day [min/day] walking. Analysis of the difference's values in TPA values between men and women classified into low, medium, and high PA groups showed significant differences only in the group of respondents with high PA (P= .004). The energy expenditure of men with high PA levels was significantly higher compared to women with high PA levels.

A separate analysis was conducted among students according to their BMI categories: underweight, normal weight, and overweight and obese (analyzed together). BMI categories significantly differentiated Total Physical Activity values (P= .039) (Table 2). A post-hoc test revealed that underweight participants had significantly lower TPA values compared to overweight and obese individuals (P= .034). Statistically significant differences based on BMI category were observed for moderate-intensity activities.

These differences were related to the number of days per week [days/week] of activity (P= .011), duration per day [min/day] (P= .020), and weekly energy expenditure [WEE, MET min/week] (P= .010). A post-hoc test showed that underweight individuals engaged in moderate-intensity activities on significantly fewer days per week than normal-weight individuals (P= .013) and overweight/obese individuals (P= .028). Additionally, underweight individuals spent significantly less time per day [min/day] on moderate-intensity activities compared to normal-weight (P= .048) individuals and those overweight/obese (P= .021). WEE on moderate-intensity activities in underweight participants was significantly lower than in normal-weight (P= .017) and overweight/obese individuals (P= .013). In contrast, the analysis of differences in energy expenditure between underweight, normal-weight, and overweight/obese subjects showed no statistically significant differences within each PA level.

Additionally, an analysis of time spent sitting was made separately. It was observed that women (M= 299.44, SD= 84.78, Me= 330.00, Q1= 240.00, Q3= 360.00) regardless of activity level spend significantly more time sitting (P= .008) compared to men (M= 284.66, SD= 86.85, Me= 300.00, Q1= 240.00, Q3= 330.00). Significant differences were observed also in time spent sitting according to BMI category (P= .025). A post hoc test showed that underweight participants (M= 313.10, SD= 81.20, Me= 330.00, Q1= 270.00, Q3= 360.00) spent significantly more time sitting (P= .023) than normal-weight individuals (M= 292.72, SD= 85.12, Me= 330.00, Q1= 240.00, Q3= 360.00).

Discussion

The present study aimed to assess the PA level first-year university of Slovak students using a validated tool (the IPAQ-SF questionnaire), which has been widely applied in numerous representative population studies worldwide. Additionally, the study examined whether gender and BMI differentiate the amount of PA-related energy expenditure, intensity, frequency, and duration of students' efforts. The selection of this tool was guided by its standardization and universal applicability, in line with the updated version of the IPAQ protocol scores.

The results of our survey indicated that more than 76% of students reported satisfactory (moderate + high) PA levels. This finding appears positive, particularly as it aligns with the results of a 2022 survey conducted across all EU Member States[28] in which 70% of students declared that they engage in PA 'regularly' or 'with some regularity'. A slightly higher percentage of respondents (more than 80%) with satisfactory PA levels was recorded in a study by Pituk and Cagas,[29] who used the IPAQ to assess PA among Filipino students. Notably, the authors[29] found that the highest proportion of respondents (nearly 48%) had a moderate PA level. Similarly, in a study by Kitiş and Terzi,[30] the authors reported that just over 50% of students had

Table 1. Means (M), standard deviations (SD), medians (Me), quartiles (Q1, Q3) for IPAQ-SF results for all participants, and significance of differences assessed by the Mann-Whitney U test between men and women.

IPAQ	Women (n= 913)					Men (n= 401)					*P value*	Overall (n= 1314)				
	M	**SD**	**Me**	**Q1**	**Q3**	**M**	**SD**	**Me**	**Q1**	**Q3**		**M**	**SD**	**Me**	**Q1**	**Q3**
	Total physical activity [MET min/week]															
	2512.63	2343.10	1866.00	876.00	3432.00	3252.43	2780.28	2466.00	1182.00	4426.00	≤ .001	2738.40	2606.88	1992.00	960.00	3813.00
	Frequency [days/week]															
Vigorous	1.64	1.75	1.00	.00	3.00	2.20	2.01	2.00	.00	3.00	≤ .001	1.81	1.85	1.00	.00	3.00
Moderate	2.05	1.91	2.00	.00	3.00	2.38	2.01	2.00	1.00	4.00	.008	2.15	1.94	2.00	.00	3.00
Walking	4.43	2.35	5.00	3.00	7.00	4.79	2.34	5.00	3.00	7.00	.013	4.54	2.32	5.00	3.00	7.00
	Duration [min/day]															
Vigorous	41.22	46.83	30.00	.00	60.00	58.62	52.81	60.00	.00	90.00	≤ .001	46.53	49.37	30.00	.00	63.00
Moderate	44.01	45.20	30.00	.00	60.00	54.38	49.89	50.00	15.00	75.00	≤ .001	47.17	46.91	30.00	.00	60.00
Walking	63.35	50.10	60.00	30.00	90.00	61.14	47.65	50.00	30.00	90.00	.504	62.68	49.36	60.00	30.00	90.00
	Weekly Energy Expenditure [MET min/week]															
Vigorous	941.65	1397.53	480.00	.00	1440.00	1512.68	1797.15	960.00	0.00	2400.00	≤ .001	1115.91	1552.33	480.00	.00	1600.00
Moderate	533.27	703.20	240.00	.00	720.00	714.67	873.98	480.00	80.00	960.00	≤ .001	588.63	763.64	320.00	.00	840.00
Walking	1036.93	1016.54	693.00	330.00	1386.00	1025.08	941.25	693.00	396.00	1386.00	.525	1033.31	993.82	693.00	330.00	1386.00
	Level Physical Activity [MET min/week]															
Low	534.52	566.24	396.00	148.50	678.00	675.64	635.89	489.80	247.50	960.00	.057	570.71	587.08	397.00	162.50	746.25
Moderate	1588.34	643.68	1485.00	1110.00	2013.00	1742.78	745.81	1638.00	1158.00	2194.00	.072	1631.10	676.23	1512.00	1128.00	2064.00
High	4715.72	2359.66	4158.00	3078.00	5736.00	5316.23	2650.34	4491.00	3660.00	6906.00	.004	4930.34	2481.81	4275.00	3222.00	6132.00

Note: Total physical activity [MET min/week] = sum of Walking [MET min/week] + Moderate [MET min/week] + Vigorous [MET min/week]

Table 2. Means (M), standard deviations (SD), medians (Me), and quartiles (Q1,Q3) for IPAQ-SF results for all participants, and significance of differences assessed by the Mann-Whitney U test according to BMI category.

IPAQ	Underweight (n= 142)					Normal weight (n= 923)					Overweight and obesity (n= 249)					*P* value
	M	SD	Me	Q1	Q3	M	SD	Me	Q1	Q3	M	SD	Me	Q1	Q3	
	Total physical activity [MET min/week]															
	2264.37	2066.18	1851.00	594.00	3416.00	2756.58	2534.34	1992.00	977.50	3771.00	2941.33	2606.75	2064.00	1046.50	4230.00	.039
	Frequency [days/week]															
Vigorous	1.53	1.67	1.00	.00	3.00	1.84	1.85	2.00	.00	3.00	1.88	1.93	1.00	.00	3.00	.231
Moderate	1.71	1.80	1.00	.00	3.00	2.20	1.95	2.00	.00	3.00	2.24	1.98	2.00	.00	3.00	.011
Walking	4.28	2.47	5.00	2.00	7.00	4.57	2.30	5.00	3.00	7.00	4.58	2.30	5.00	3.00	7.00	.508
	Duration [min/day]															
Vigorous	37.65	43.91	30.00	.00	60.00	46.46	48.73	30.00	.00	65.00	51.83	53.88	45.00	.00	90.00	.064
Moderate	37.15	39.81	30.00	.00	60.00	47.68	47.21	30.00	.00	60.00	51.02	48.88	45.00	.00	60.00	.020
Walking	61.20	51.15	60.00	30.00	90.00	62.85	49.60	60.00	30.00	90.00	62.88	47.60	60.00	30.00	90.00	.740
	Weekly Energy Expenditure [MET min/week]															
Vigorous	824.28	1251.29	360.00	.00	1200.00	1118.01	1548.07	480.00	.00	1440.00	1274.47	1698.27	480.00	.00	1920.00	.099
Moderate	437.78	610.37	200.00	.00	640.00	594.86	767.21	320.00	.00	900.00	651.58	818.62	360.00	.00	960.00	.010
Walking	1002.32	1024.75	594.00	264.00	1386.00	1043.30	1003.05	693.00	346.50	1386.00	1013.99	943.60	693.00	396.00	1386.00	.497
	Level Physical Activity [MET min/week]															
Low	501.02	546.63	396.00	165.00	594.00	570.82	577.33	413.50	148.50	748.50	629.85	657.12	462.00	148.50	891.00	.719
Moderate	1681.81	685.12	1548.00	1070.00	2106.00	1626.04	687.91	1485.00	1130.50	2059.80	1625.55	628.42	1611.00	1110.00	2028.00	.822
High	4339.90	1898.10	3934.50	3039.00	5003.25	4970.51	2540.39	4350.00	3186.00	6228.00	5070.53	2502.20	4452.00	3519.00	6453.00	.177

Note: Total physical activity [MET min/week]= sum of Walking [MET min/week] + Moderate [MET min/week] + Vigorous [MET min/week].

a moderate PA level, while nearly 30% had a high PA level. It is worth noting that the distribution of moderate and high PA levels in these studies differs significantly from data obtained in a study of Australian university students, where nearly all respondents (92%) were classified as engaging in PA at either moderate (36%) or high (56%) levels. According to the authors, it is likely that these results may be influenced by overestimation by respondents,[31] although they do not rule out the possibility that the specific group of participants (medical students) may be more likely to engage in PA compared to the general population. The results of our survey are consistent with previous findings, documenting that just over 75% of participants engage in PA at a moderate or high level. However, in contrast to other studies,[29,30] the largest group in our study (more than 41%) were students with high PA levels, while more than 35% reported moderate levels, which is broadly in line with the findings of Sahlqvist et al.[31] These observations also align with the 2022 Eurobarometer study, which reported that Slovakia has the highest percentage of individuals (40%) among all European countries declaring that they engage in vigorous physical activity of 4–7 days per week. A further 40% of respondents from Slovakia reported undertaking such activities 1-3 times a week. Contradictory to our reports are studies reporting low PA levels of students in Turkey[32] and Romania.[14] In Turkey, nearly half of the surveyed students were found to have insufficient PA levels. By contrast, in Romania[15], the percentage was around 40% of those surveyed. Although these studies were limited to local surveys of undergraduate and graduate students, similar trends were confirmed in a cross-sectional study conducted earlier among students from 24 low- and middle-income countries.[33] The authors observed that more than 42% of the students presented a low PA level, 36.5% a moderate level, and only 21.2% showed a high level.

In recent years, research has emphasized that most adolescents and adults in low-income countries do not meet PA guidelines,[34] and a recent WHO international survey revealed that physical inactivity levels are highest in lower-middle-income countries.[35] It is indicated that economic inequalities, particularly in high- and middle-income countries, contribute to reduced PA participation and widen gender disparities in adherence to global PA guidelines.[36] Thus, identifying gender differences in PA levels within the academic population remains a key area of study.

Numerous previous studies across various countries, conducted in both secondary schools and universities, have consistently shown that men tend to be more physically active than women.[12,14,30,32,37] The same trend was confirmed in the study conducted in 2012-2014 on a sample of 1,742 students from Košice universities[17]. The disparity in commitment to undertaking PA is evident from early school years[38] and persists throughout adulthood. Although the minimum PA dose recommendations are the same for men and women, women are more likely to fail to meet them.[38] One potential explanation for the low levels of PA may be a lack of awareness of the guidelines and knowledge of the recommendations for undertaking PA. For example, according to data collected by Werner & Betz,[39] among college students, 67.6% were aware that PA recommendations exist, but only 26.8% could accurately report them, while in a study by Abula et al.,[40] only 4.4% of the students surveyed had correct knowledge of PA recommendations.

In the present study, a comparison of the energy expenditure of male and female students according to the IPAQ-SF protocol clearly confirmed that women are less physically active than men. This result aligns with trends observed in earlier Slovak studies.[17] In the current study, men had a significantly higher TPA. Furthermore, they were characterized by higher WEE on moderate and vigorous intensity activities. Slovak male students engaged in these activities significantly more often than women and devoted more time to them. Furthermore, it is worth noting that within the high PA group, men had significantly higher energy expenditure than women. These findings support evidence from previous observations in other countries,[32,37] where researchers, similar to the present study, identified gender differences in these variables. However, similar to our study, they did not observe differences in MET values for walking.

Another important issue is the assessment of time spent sitting. An alarming report was the published results of a meta-analysis,[41] suggesting that time spent sitting has increased over the past 10 years among university students. The authors noted that university students lead more sedentary lifestyles than the general young adult population. At this point, it also seems important to note the observations of researchers,[30,42,43] in which the authors make it clear that sedentary behaviour does not necessarily mean the absence of PA. The researchers highlight that some individuals may engage in moderate to vigorous PA yet still exhibit a sedentary lifestyle. In our study of Slovakian students, we found that women, regardless of PA levels, spent significantly more time sitting compared to men. In contrast, a study involving Turkish students[32] did not report such correlations. The discrepancy in reported results may stem from differences in measurement tools, as Chastin et al.[44] indicated large variations in sitting time estimation between the IPAQ long form and active PA levels, suggesting that IPAQ significantly underestimates sitting time.

It is widely accepted that a sedentary lifestyle is associated with an increase in BMI, particularly among individuals who do not meet moderate-to-vigorous PA recommendations,[45] though it is important to stress that this is just one contributing factor, alongside others such as dietary habits. A sedentary lifestyle, as noted above, should be considered in conjunction with PA levels. Presumably, this is why Peterson et al.[42] did not find an association between sitting time and increased BMI in their study, as participants engaged in an average of just over one hour per day of MVPA-level activity. In our study, we observed significant differences in time spent sitting according to BMI category. Contrary to previous reports, our results indicated that underweight students spent significantly more time sitting than those with normal weight. Although both the median and mean sitting times were very similar between normal weight and overweight/obese students, no significant differences were observed between underweight and overweight/obese individuals. Our findings do not support the results of 55 studies in which researchers observed an association between time spent sitting and overweight/obesity [46]. However, it is important to note that those studies were conducted among older adults, whereas our research focused on university students. In contrast, Chastin et al. [44] indicated that the accuracy and precision of self-reported sitting time measured by the IPAQ questionnaire are low. The authors observed weak correlations between the sitting time reported by participants in the IPAQ and the time objectively measured using accelerometers.

Additionally, we found that underweight individuals had significantly lower energy expenditure for TPA compared to normal-weight and overweight/obese individuals. This is primarily due to significantly lower energy expenditure in the moderate-intensity category. Underweight people engaged in moderate-intensity PA significantly less frequently than the rest of the respondents and devoted significantly less time to it compared to normal-weight and overweight/obese individuals. We recommend treating this observation with caution due to

the small number of underweight students (n= 142) compared to students with normal weight and overweight/obese. In the current study, no differences in energy expenditure were observed between underweight, normal-weight, and overweight/obese participants within different PA levels, which is generally in some agreement with previous findings by other authors.[32,46]
This study has some limitations; therefore, results must also be interpreted in these contexts. First, in this large-scale survey, all results obtained from respondents are only a measure of their subjective assessment and were not measured by objective methods. The second point relates to the IPAQ-SF tool. This tool provides quantitative data on PA but does not offer insights into the underlying reasons for specific behaviours. Additionally, in our view, the scoring and exclusion criteria contained in the IPAQ Guidelines may introduce distortions in the results. According to the creators, this procedure aims to eliminate outliers that could discard the correct picture of the study population. However, many researchers using this questionnaire to assess PA face the challenge that, despite the short recall period of seven days, respondents may find it difficult to understand the questions and estimate the time spent on moderate PA, vigorous PA, walking, or sitting. The researchers point to a possible overestimation or underestimation of the time spent on individual activities, as mentioned above. Many studies have questioned the reliability of the IPAQ, indicating that the correlation between the IPAQ and objective measures of activity or fitness in the large majority of studies was lower than the acceptable standard.[47,48] Moreover, the survey administration method, such as conducting it online, may also influence the reported results. Additionally, respondents' subjective understanding of effort intensity and perceived PA levels may vary, further affecting data accuracy. Nonetheless, the widespread use of the questionnaire across different countries enables global PA assessments and facilitates comparisons of quantitative findings, allowing for the estimation of PA levels. Third issue is that our research is not conducted in relation to environmental and economic factors (e.g., place of permanent residence, monthly budget of students), which in this case may contribute to limit the findings and it's important to acknowledge for future research. It should also be noted that the study may be self-selection bias, as students who are more active on social media were more likely to participate, which may affect the generalizability of the results. However, the link was distributed broadly across all public universities, which increases the variability of the sample and reduces the risk of systematic bias. Another important issue that should be highlighted as significant in limiting applications is the significant gender imbalance (more than twice as many women as men), as this may affect the representativeness of the results for men. Finally, it should be added that the study only covered students who practiced recreational sports, excluding those who practiced competitive sports and those studying physical education. This is an important exclusion, which limits the possibility of generalizing the results to the entire student population. Therefore, the results should be interpreted in the context of the sample selection criteria and refer only to students who engage in recreational physical activity, not to the entire academic population.

Practical Applications

The findings of this study provide practical applications valuable insights for coaches, sport scientists, and health professionals working with university populations. The identification of significant gender and BMI-related differences in physical activity (PA) patterns can inform the development of more tailored and inclusive physical activity programs. Specifically:
(1) Gender-specific interventions may be necessary, as women reported significantly lower participation and energy expenditure in moderate and vigorous activities. Coaches and program designers should consider strategies that increase engagement and motivation among female students, potentially by offering varied and socially supportive PA opportunities. Interventions promoting PA should take into account a range of behavioural determinants.[49] The literature suggests[49] that personalized approaches and PA sessions should be considered. In addition, online interventions, which have been proven effective in studies[50], are worth considering.
(2) BMI-specific findings suggest that underweight individuals are at risk of lower PA participation, particularly in moderate-intensity activities, and spend more time sitting. This group may require closer attention from both athletic trainers and health educators, as physical inactivity combined with high sedentary time may increase health risks, even in individuals with a "normal" or low BMI.
(3) High-PA male students demonstrated significantly higher energy expenditure compared to females in the same PA category, indicating that even within the same classification, actual activity output may differ. Sport scientists and performance specialists should be cautious when comparing PA levels solely based on categorical classification and consider using absolute energy expenditure metrics for more accurate assessments.
(4) The widespread use of the IPAQ-SF allows for international comparability of PA levels, but practitioners should be aware of its limitations, including self-report bias, potential misinterpretation of intensity levels, and influence of online administration. Complementing questionnaires with objective tools (e.g., accelerometers) could provide a more comprehensive picture of PA behavior.

Conclusions

The results of our study indicate that more than 76% of students engage in moderate or high levels of physical activity, with over 41% achieving a high PA level. We observed a clear disparity in PA levels between men and women, with women exhibiting significantly lower energy expenditure in moderate- and vigorous-intensity activities compared to men. Slovak female students engage in moderate and vigorous activities less frequently than their male counterparts and spend less time on such activities. In our view, these findings highlight the need for targeted interventions to encourage the remaining 24% of inactive respondents to increase their PA levels and to promote greater PA participation among women. It is important to emphasize that the IPAQ test protocol follows specific criteria for classifying PA levels, which may not necessarily align with WHO recommendations for physical activity.[15] An interesting, albeit unexpected, finding that contradicts common assumptions is the observation that underweight students spend significantly more time sitting than those with normal weight. Further research should explore potential explanations for this phenomenon.

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Ethical Committee approval

The protocol was approved by the Human Research Ethics Committee of Pavol Jozef Šafárik University in Košice (approval No. PJSU-05/2023). This study was conducted in accordance with accepted ethical standards and was conducted in accordance with the Helsinki Declaration.

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The authors have no conflicts of interest to declare.

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Author-s contribution

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